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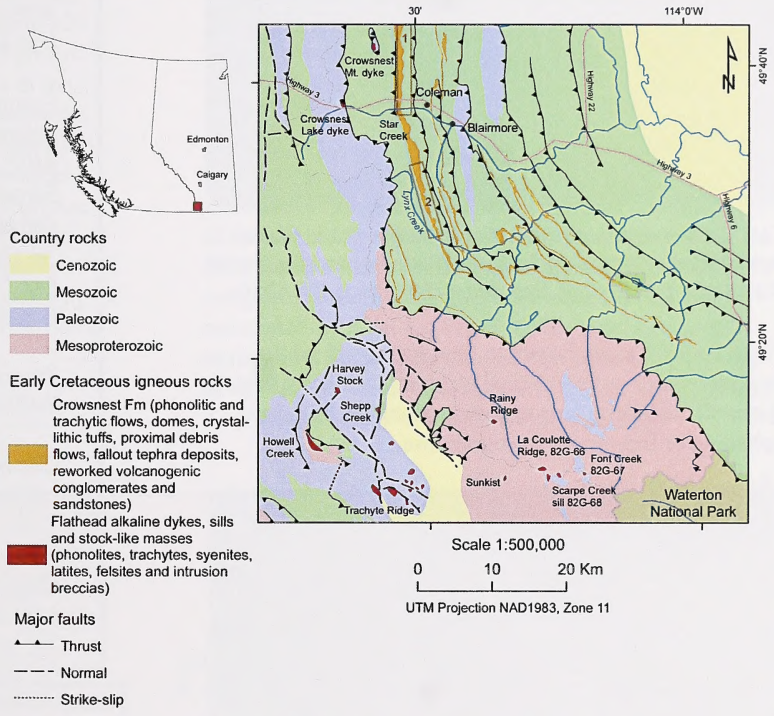
Rock Chips

Summer 2009

Alberta Geological Survey

Metal Potential of the Crowsnest Volcanics and the Flathead Intrusive Igneous Rocks in Southwestern Alberta

Continuing a series of Rock Chips summaries of igneous activity in Alberta, this article reviews metal potential of the Early Cretaceous (ca. 100 Ma) intrusive and volcanic rocks in southwestern Alberta. Alkaline dykes, sills and stock-like masses of predominantly trachytic and phonolitic composition, known as "Flathead Intrusions," crosscut the Mesoproterozoic (Purcell Supergroup), Paleozoic and Mesozoic strata in the Flathead – Crowsnest Pass – Clark Range region of southwestern Alberta and adjacent southeastern British Columbia. These intrusions are coeval and chemically similar to the so-called "Crowsnest Volcanics," which comprise domes, proximal debris flows, crystal and lithic tuff, and fallout tephra deposits, as well as reworked volcanogenic conglomerates and sandstones of the Lower Cretaceous Crowsnest Formation exposed west of Blairmore along Highway 3 in southwestern Alberta. Due to the fact that the Crowsnest Volcanics consist mainly of airborne debris, the Early Cretaceous event must have involved destructive, explosive eruptions that may have had similarities to the catastrophic 1980 eruption of Mount St. Helens. Several styles of disseminated precious and base-metal mineralization related to the Flathead Intrusions and Crowsnest Volcanics are similar to the syenite, intrusion-related deposits in Yukon (e.g., Brewery Creek), Montana and South Dakota (e.g., Zortman, Golden Sunlight, Landusky deposits). To further evaluate their metal potential, AGS studied the Early Cretaceous igneous rocks of southwestern Alberta in the field during the summer of 2008.



Simplified geological map showing distribution of Early Cretaceous igneous rocks in Crowsnest Pass-Clark/Flathead Ranges of southwestern Alberta and southeastern British Columbia, NTS 82G.

Cretaceous Flathead Intrusions in the Clark Range Area, Southwest Alberta

Early Cretaceous intrusions, ranging from dykes and sills a few metres thick to stocks and plugs up to 1200 m in diameter, composed predominantly of phonolites, trachytes and porphyritic syenites, are associated with normal and tear faults in the Flathead area of southeastern British Columbia (e.g., Howell Creek,

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Trachyte Ridge) and in the Clark Range area along the provincial border (Rainy Ridge, La Coulotte Ridge, Scarpe Creek, Font Creek). In Alberta, these intrusions cut clastic strata of both the Mesoproterozoic Purcell Supergroup and Cambrian Flathead Formation.

Early Cretaceous trachyte sills (outlined in red) emplaced into the layered Mesoproterozoic clastic strata of Roosville Formation, Purcell Supergroup, at La Coulotte. East view of Clark Range, SW Alberta.

Fresh rock faces are brown to light grey, with white or pink tabular or lath-shaped phenocrysts of sanidine (potassic feldspar) up to several cm long set in a dense aphanitic or fine-grained groundmass.

A close-up view of the upper contact of a Cretaceous trachyte sill (lower part of image) and green argillite (upper part of image) of the Mesoproterozoic Roosville Formation at La Coulotte. The sill is 7-8 metres thick and dips south at 11 degrees. Note white laths of sanidine (potassic feldspar) phenocrysts in a dense brown groundmass of the intrusion and malachite staining in the argillite above.

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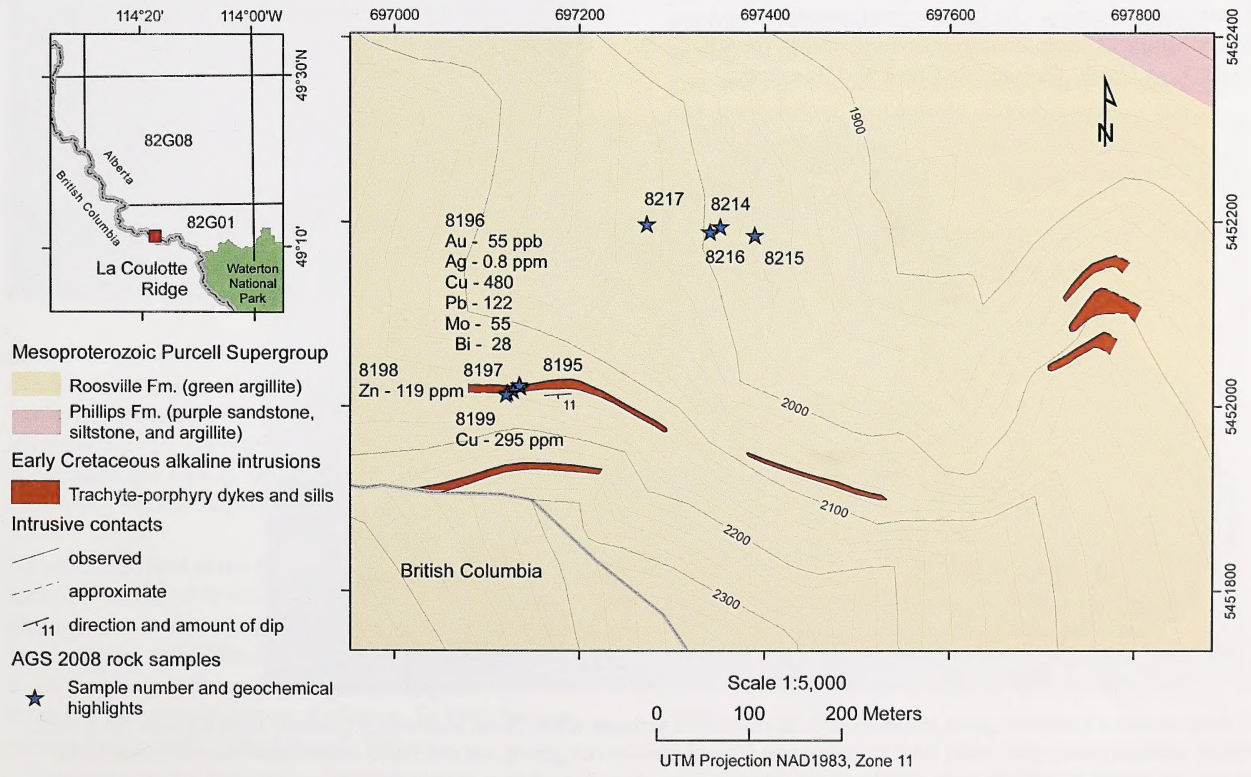
Analcime, nepheline and other feldspathoids are common in these rocks, and some varieties also contain dark-green elongate phenocrysts of aegirine and/or aegirine-augite (sodium-rich clinopyroxene). The disseminated precious and base-metal mineralization associated with these intrusions has been known since the 1960s. In the Flathead area of southeastern British Columbia, a drillhole through the Paleozoic pyritic, silicified limestone hosting Cretaceous syenite and breccia intrusions at Howell Creek returned an average grade of 1.3 g/t gold (Au) over a 59 m interval. At Trachyte Ridge, syenite-hosted, centimetre-wide, quartz-magnetite-pyrite veins commonly contain >30 g/t Au, with the highest grade reported at 620 g/t Au. Metal exploration during the 1960s and 1970s in the Clark Range area of southwestern Alberta discovered disseminated sulphide mineralization both in the Early Cretaceous intrusions and clastic sedimentary rocks along the intrusive contacts grading up to 0.72 g/t Au, 32.57 g/t silver (Ag) and 0.43% copper (Cu). Similar dykes that intrude the Paleozoic strata at Crowsnest Mountain, Crowsnest Lake and Star Creek contain up to 367 g/t vanadium (V), 160 g/t zinc (Zn) and 81 g/t lead (Pb), respectively.

During the summer of 2008, AGS carried out field mapping and rock sampling of several known Early Cretaceous intrusive occurrences in the Clark Range of southwestern Alberta, including Font Creek, Scarpe Creek sill (AGS mineral occurrence 82G-68) and La Coulotte Ridge dyke-sill complex (AGS mineral occurrence 82G-66). New geochemical analyses from 14 rock samples indicate up to 55 ppb Au, 3.8 g/t Ag, 480 g/t Cu, 122 g/t Pb, 70 g/t tungsten (W,) 55 g/t molybdenum (Mo,) 79 g/t arsenic (As,) 28 g/t bismuth (Bi,) 5 g/t antimony (Sb) and 1 g/t mercury (Hg.) The highest metal concentrations are found in quartz arenites and argillites at the contacts with the gently dipping Cretaceous trachyte-porphyry dykes and sills. At La Coulotte Ridge, the Au-Ag-Cu-Pb-Mo-Bi enrichment occurs in green argillites of the Mesoproterozoic Roosville Formation just below the lower contact of a trachytic sill (7-8 metres thick), although anomalous Cu contents and malachite staining occur on either side of the sill. At Scarpe Creek, a trachyte-porphyry sill (3 m thick) emplaced into quartz arenites and pebble conglomerates of the Cambrian Flathead Formation is associated with Au-Ag-Pb-W-As-Sb-Hg-thorium (Th) enrichment immediately above the intrusion. Analyses of the intrusions indicate up to 246 g/t Zn, 28 g/t W and 12 g/t As, coupled with elevated Sb and Hg.



Map of trachyte intrusions at La Coulotte Ridge, Clark Range area, showing location of the 2008 rock samples and geochemical highlights

Early Cretaceous Crowsnest Volcanics, Southwest Alberta

Numerous petrological studies of the volcanic and volcaniclastic rocks of the Early Cretaceous Crowsnest Formation classify the rocks as garnet-analcime phonolites, including a type-locality "blairmorite" (a volcanic rock with abundant analcime phenocrysts and rare, if any, feldspar phenocrysts) and trachyte. The Crowsnest Volcanics, which are coeval and chemically similar to Flathead Intrusions, have been a metal exploration target since the discovery of up to 0.21 g/t Au with minor galena and chalcopyrite in melanocratic, pyrite-rich pyroclastics at Iron Ridge near Coleman in the Crowsnest Pass in the 1980s. Pyrite concentrates from this occurrence assayed up to 2.55 g/t Au, and extensive rock and stream sediment sampling in the areas between Ma Butte - McGillivray Ridge - Wedge Mountain - Highway 3 and in the Lynx Creek area indicated up to 0.05 g/t Au. Subsequent regional work by Alberta Geological Survey, Geological Survey of Canada and industry under the Mineral Development Agreement in the 1990s confirmed anomalous gold values of up to 0.05 g/t at Iron Ridge and reported local concentrations of up to 14 ppb Au, 0.3 g/t Ag, 299 g/t V, 227 g/t Cu, 182 g/t Zn, 99 g/t Pb, 7 g/t Mo, 10 g/t W, 25 g/t As, 21 g/t Bi and 5 g/t Sb from the Crowsnest volcanics. The latter was suggested to be a likely source of anomalous gold concentrations found in the Lost Creek, Carbondale Creek and Racehorse Creek drainages. Based on seven rock samples from the Crowsnest volcanics collected by AGS in the spring of 2008, a coarse-grained volcanogenic sandstone from a Highway 3 roadcut outcrop east of Coleman returned up to 7 ppb Au, 0.8 ppb platinum (Pt), and 1.4 ppb palladium (Pd) and a green phonolite breccia with feldspar-calcite blebs and veins from a pipeline trailcut at Star Creek yielded up to 86 g/t Cu coupled with 0.5 ppb Pt, 1.4 ppb Pd and 7.4 g/t W.

The metal- and pathfinder-element signatures of the Early Cretaceous igneous rocks in southwestern Alberta are consistent with alkaline intrusion-related and epithermal disseminated precious base-metal deposits elsewhere and may warrant further exploration, although many of the intrusive occurrences are within the Castle Mountain Special Management Area and the Rocky Mountain Forest Reserve area.

Elevated base metals and locally anomalous gold, coupled with the Mo-W-As-Bi-Sb signature of the Crowsnest Formation, may indicate potential for shallow, auriferous, volcanogenic, massive sulphide (Au-VMS), as well as epithermal and/or hot spring mineralization associated with felsic volcanic domes and flows. In addition, some of the gold anomalies spatially associated with reactivated faults, post-emplacement shear zones and thrusts might indicate structurally controlled vein/ disseminated gold-silver mineralization. ❖

A close-up view of Crowsnest garnet phonolite from a pipeline trailcut exposure at Star Creek, southwest of Coleman. There are large pink to white, tabular, sanidine phenocrysts; round, black melanite grains (<5 mm) (titanium-rich garnet), and rare, round, amber-brown analcime grains set in green, fine-grained groundmass owing its colour to the presence of tiny, dark-green aegirine needles. After the volcanic event, a fracture through both the primary minerals and the surrounding matrix was filled with white calcite.

The Career of Dr. József Tóth

In this edition of Rock Chips, we begin a regular feature on geologists and engineers who have made or are continuing to make important contributions to our understanding of geology and geological engineering through their careers in Alberta. In this edition, we examine the career of Dr. József Tóth.

József Tóth studied geophysics for 4 1/2 years at the School of Mining and Geodesy in Sopron, Hungary, but left the country before graduating due to the Soviet invasion in 1956. He received an M.Sc. degree in geophysics and a Ph.D. in hydrogeology from the State University of Utrecht, the Netherlands.

He spent 20 years at the Alberta Research Council as a hydrogeologist, 12 of which as head of the Groundwater Department. In this capacity, he oversaw the scientific and technical activities of the department, including a ten-year-long hydrogeological mapping program covering the entire province of Alberta. In 1980, he was named the Council's first Research Fellow.

Dr. Tóth introduced hydrogeology at the University of Alberta (U of A) in 1966 and at the University of Calgary in 1978. He joined the Geology Department of the U of A as full professor in 1980. He taught there until his retirement as professor emeritus in 1996. He has presented courses and worked in various capacities in Australia, Brazil, France, Germany, Ghana, Italy, Holland, India, Kenya, Mexico, China, Spain, Sri Lanka, Switzerland, Thailand, the United Kingdom and the United States. He taught at the Eötvös Lóránd University in Hungary as titular university professor between 2005 and 2008.

Dr Tóth founded the Canadian National Chapter of the International Association of Hydrogeologists (IAH) in 1972 and served as its president until 1984. He was the Hydrogeologist Member of the Technical Advisory Committee to Atomic Energy of Canada Ltd. between 1981-1985 and 1989-1996.

The focus of Tóth's research was gravity-driven groundwater flow. His more than 90 publications stimulated extensive research internationally on problems of soil salinization, eco-hydrology, slope stability, geothermal heat transport, transient flow on geological time scales, radioactive waste-isolation, groundwater resources development, land-use planning and management, and petroleum hydrogeology. His "scientific autobiography," a book on the topic, was published by Cambridge University Press in April 2009.

Dr. Tóth's contributions have shifted basic paradigms, expanded the scope and modified the definition of hydrogeology. For his work, he has received numerous distinctions, including the Geological Society of America's first O.E. Meinzer Award, the IAH's President's Award, the Prix Robert N. Farvolden Award of the Canadian Geotechnical Society, the National Ground Water Association's M. King Hubbert Science Award and the C.V. Theis Award of the American Institute of Hydrology. The Prix J. Tóth Award was established by the Canadian National Chapter of IAH for the "Best Student Paper in Canadian Hydrogeology - Meilleur article étudiant Canadien en hydrogéologie."

He now lives with his wife in Edmonton, Alberta, and is still active at the University of Alberta in the hydrogeology lab. ❖

Uranium Potential of Southern Alberta

In 2006, Alberta Geological Survey (AGS) initiated a program to assess the regional uranium potential of southern Alberta. This program was started after more than 1 million hectares were staked by junior exploration companies to renew exploration efforts in this area after a 20-year-long hiatus, when uranium prices were depressed and the prospect of developing nuclear energy was very unpopular.

In the last decade, nuclear power is increasingly seen as a way to produce emission-free energy. There are 133 nuclear-power reactors under construction around the world. In Alberta, Bruce Power is proposing the construction of a nuclear reactor in the Peace River area.

Dwindling supplies of known uranium resources resulted in a uranium-oxide price spike from US$7/lb in 2001 to more than US$130/lb in 2007. Since then, increased exploration activities were successful in increasing resources by 15%. The global economic downturn of late 2008 and early 2009 resulted in a price drop of uranium oxide to approximately US$40/lb., however, there is still a demand for uranium to supply the projected development of nuclear power plants worldwide.

From 2005 to 2008, exploration companies investigated the uranium potential of southern Alberta through airborne surveys, ground surveys, mapping and drilling campaigns. To gain a better understanding of the potential of the area, Alberta Geological Survey initiated field studies to describe the geology and geochemistry of the areas of greatest interest in southern Alberta.

Uranium Deposit Model and Mining Methods

The model that exploration companies have been using from the 1980s to present in southern Alberta is that of sandstone-hosted uranium deposits, similar to deposits that are currently being mined in Wyoming. These deposits occur in buried sandstone channels. The model suggests that oxidized groundwater picks up uranium from surrounding feldspar-rich sandstones that contain elevated background amounts (up to 15 ppm) of uranium. The uranium-bearing groundwater migrates along the buried sandstone until it hits a geochemical reduction zone. Here, the uranium is precipitated out of solution and is concentrated, potentially creating a low-grade, small uranium deposit. These deposits may be economically viable due to the in situ mining method that allows low-cost extraction of low-grade uranium without moving the rock.

The in situ leach-mining method was developed in the former Soviet Union and U.S.A. in the 1960s. Currently, about 20% of the world's uranium is produced by these low-impact, in situ recovery mines. Working on similar principles that allowed the deposit to form in the first place, an oxidizing solution is injected into the ore body, releasing uranium from the rock. The uranium-bearing solution is then pumped to the surface, and the uranium is precipitated out. Once the uranium is extracted, the oxidizing solution can then be reinjected for further uranium extraction. Monitoring of the mining process ensures environmental safety of the operation, and when the mining is complete, the ground surface remains undisturbed with little reclamation necessary.

In situ leach mine at Smith Ranch, Wyoming. The white barrels are covering well heads of injection and production wells. Two million pounds of uranium oxide are produced yearly from sandstone ores that have an average grade of 150-180 ppm uranium.

Field Program

Over three field work seasons, we have studied outcrops of potentially uranium-bearing Upper Cretaceous and Tertiary rock formations in southern Alberta. Samples were collected and assayed for multiple elements, including uranium and uranium-tracer elements, and thin sections were made from representative rock samples from most formations. The thin-section study showed that most rocks are fine grained, with significant chert content and very low feldspar content. Chemical analysis revealed very low (<2 ppm) background uranium values.

A small program of well-water sampling confirmed radioactive anomalies reported by exploration companies and established background levels of radioactive elements in groundwater.

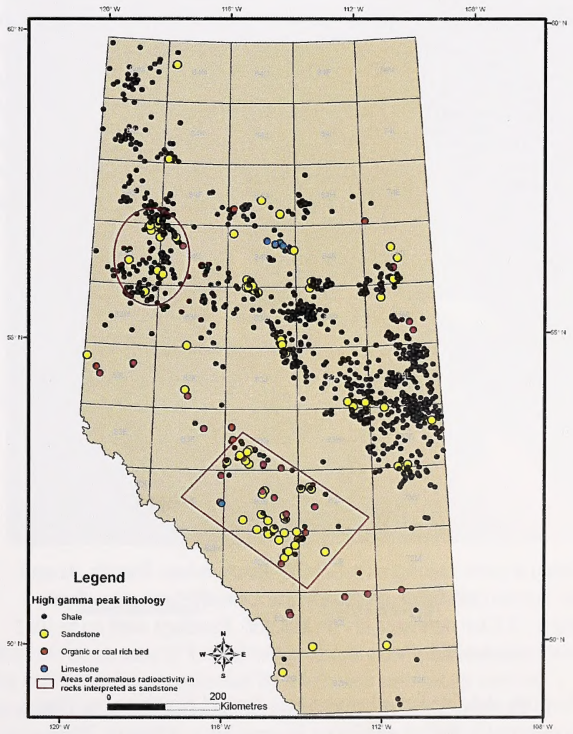
AGS staff member Tanya Matveeva measuring radioactivity in a thorium-rich sandstone bed of the Milk River Formation.

Alberta Geological Survey studied radioactive occurrences reported by exploration companies and confirmed that one outcrop of the organic-rich shale of the St. Mary River Formation contains 29 ppm uranium. Another outcrop had fossil-bone material in mudstones of the Willow Creek Formation with 3810 ppm uranium. A new occurrence was discovered along the bank of the Oldman river. Here a siltstone bed of the Willow Creek formation contains up to 158 ppm uranium.

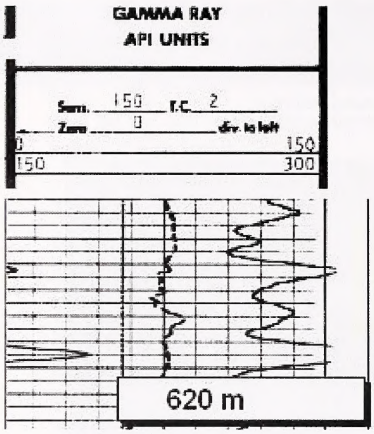
Oldman uranium occurrence showing uranium values for two sample sites. Basant Kafle is collecting samples for analysis and thin-section study.

Potential of Oil and Gas Geophysical Logs in Uranium Exploration

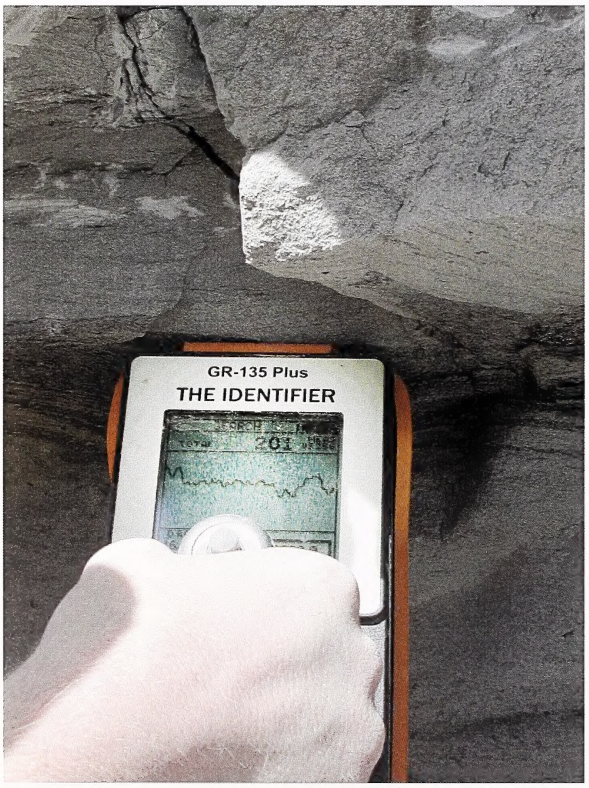
Geophysical logging is widely used in uranium exploration and resource evaluation. In Alberta, geophysical logs from thousands of oil and gas wells covering nearly the entire province are available to identify anomalous radioactive signatures in the subsurface. We evaluated approximately 48 000 logs across Alberta to locate wells where the gamma-ray signature indicated a possible radioactive anomaly. More than 6000 wells contained anomalously radioactive rocks within 500 m of the surface. Of these, more than 800 logs were studied in detail to confirm the anomaly and interpret its origin. The majority of anomalies identified are in rock formations known to have slightly anomalous uranium content, but do not fall under sandstone-hosted deposit model-type mineralization and are unlikely to have economic potential. However, concentrations of wells with anomalous, radioactive signatures in rocks, interpreted as sandstones, were located along a trend parallel to the mountain front southwest of Edmonton, and also in a large area around Grande Prairie. Both warrant further investigation.



Map showing oil and gas wells with anomalously radioactive intervals within 500 m of the surface. Rock type was interpreted using a combination of gamma-ray, resistivity, density and porosity geophysical well logs.



Drill cuttings (rock chips) from well 06-19-011-27W4, from a depth of 618-627 m. A gamma-ray peak of 195 API (2-3 times higher than background) occurs at 620 m depth on the corresponding geophysical well log.



Taking a meter reading on a GR-135 Spectrometer. Results showed an Oldman radioactive anomaly in the Oldman River valley, south shore, 12.5 km northeast of Fort McLeod. Readings went up to 1002 counts per second.

A more detailed study was conducted for the area that is currently being explored in southern Alberta. This study identified anomalously radioactive intervals in the geophysical logs from the Upper Cretaceous and Tertiary formations in the Claresholm area. Drill

Sandstone channels in Willow Creek Formation on the north shore of Waterton River, 6.3 km nothwest of Glenwood.

cuttings (small chips of rock collected at the time of drilling) from these intervals were studied at the ERCB Core Research Facility in Calgary. Study of cuttings proved useful in identifying rock types, but sample volume was insufficient to measure uranium content.

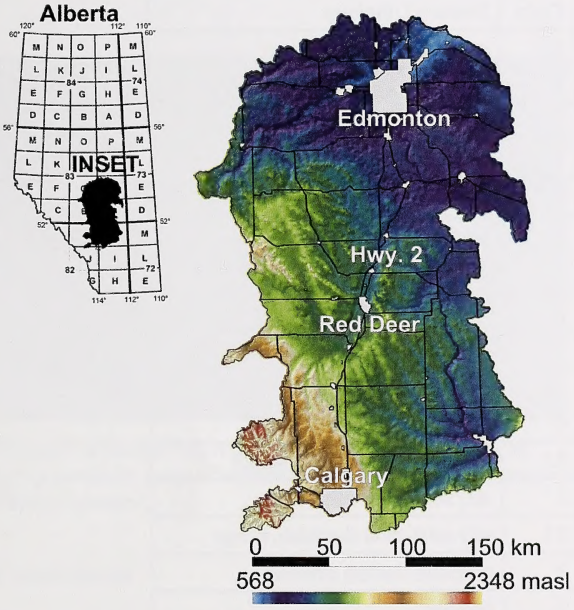
Both field work and study of existing datasets confirmed that anomalous concentrations of uranium exist in rock outcrops and groundwater. This suggests that uranium was mobilized and concentrated in clastic strata.

Conclusion

The AGS program identified areas with elevated uranium concentrations, and has presented several ways in which uranium potential can be further studied by both industry and government agencies. Information collected by AGS, as well as that released through assessment reports by industry, will play key roles in uranium exploration and assessment in southern Alberta. ❖

A New Approach to Mapping the Bedrock Topography and Thickness of Overlying Sediments in the Edmonton-Calgary Corridor, Central Alberta

According to Alberta Environment (AENV), groundwater is an essential source of drinking water for approximately 90% of rural populations in Alberta. More than 200 communities and public facilities regulated by AENV use groundwater-based sources to provide drinking water for approximately 110 000 users. In areas of rapid urban expansion, like the Edmonton-Calgary corridor (ECC), geological information, such as bedrock topography and sediment thickness maps, provides a basis for understanding the extent of water-bearing sediments. This understanding is important in meeting the goals of the Alberta Government's Water for Life Strategy, and making decisions under Land Use Framework policies.

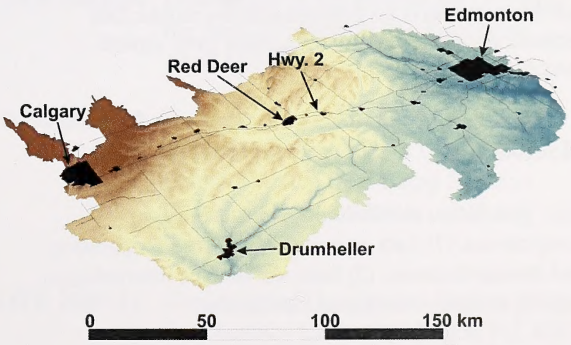


Bedrock topography map of the ECC. Map is accented by hill shaded relief and a vertical exaggeration of 20. Elevation of bedrock in metres above sea level (m asl) is defined by the colour ramp. Inset depicts location of the Edmonton-Calgary corridor (ECC).

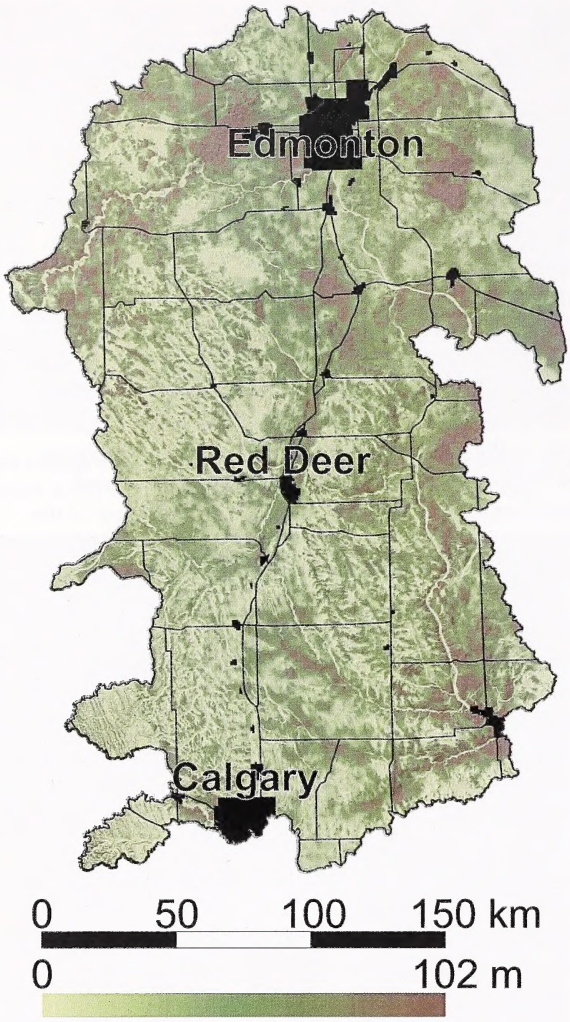
In response to increasing rates of urbanization and industrialization in the ECC and the foreseeable pressures that this will have on existing groundwater supplies, Alberta Geological Survey (AGS), in partnership with AENV, has initiated a multiyear project to characterize nonsaline aquifer complexes in the ECC.

To assist in making land-use planning decisions and effective groundwater protection policies, a thorough understanding of the bedrock geology, preglacial sediments and glacially derived sediments within the area is essential. These deposits form significant areas of recharge, contain both local and regional aquitards and include numerous producing aquifers. As an initial step in the geological modelling process, preliminary bedrock topography and sediment thickness maps have been completed for the ECC. An overview of the methodologies and protocols used to complete these maps is discussed below.

Recent advances in data storage and retrieval have allowed for the collection and extensive use of water well, geotechnical and oil and gas records, as well as field-based observations compiled through mapping exercises at AGS. These advances enable new automated methods that enable geological knowledge to be extracted from these large datasets and interpreted quickly. Using readily available GIS-based analysis functions and interpolation techniques, such as kriging, extensive datasets of subsurface information were integrated and analyzed to generate bedrock topography and sediment-thickness maps for the ECC.



Bedrock topography of the Edmonton-Calgary corridor looking to the northwest. Map is accented by hill-shaded relief and a vertical exaggeration of 20. Urban centres and roads are offset vertically by 3 kilometres.



Drift-thickness map of the Edmonton-Calgary corridor. Drift thickness in metres is defined by the colour ramp. Vertical exaggeration of map is 20.

Methodology

Map generation methodology consists of four components: (1) data acquisition; (2) data preparation and standardization; (3) bedrock surface interpolation; and (4) sediment thickness calculation.

In the working database, more than 22 000 different combinations of descriptors were used by water-well drillers to describe the various geological strata or lithologies in the ECC. Manual inspection of every combination was not feasible because of time constraints. Therefore, an automated approach that identified unique combinations of descriptors was constructed for the database. This method was designed to simplify and streamline descriptors used to describe the same lithologies. This approach identified 2611 unique combinations of descriptors used to describe lithologies in the ECC. To further condense the descriptors and to provide users with a standardized set of geological descriptions, unique combinations of descriptors were manually translated into one of 25 primary lithologies (see table). Wells containing undefined or nongeological descriptions, such as "sea shells, unknown, see comments, hard ledges, etc." are inspected manually to determine lithology. In many cases, these wells are excluded from the dataset due to insufficient geological data. To capture the standardized lithology values, a new lithology field in the database was created and populated using the 25 standardized lithology codes. To create the bedrock topography and sediment thickness maps, wells that contain bedrock lithologies in the standardized lithology field of the database were extracted and used in the interpolation process.

AGS primary lithology legend

Code	Primary Lithology
13	no obvious material code
12	covered: missing; previously bored
11	fill (including topsoil, waste)
10	organic
9	clay, silty clay
8	silt, sandy silt, clayey silt
7	sand, silty sand
6	gravel, gravelly sand
5	clay-clayey silt diamicton
5.1	clay-clayey silt diamicton, stoney
4	silt-sandy silt diamicton
4.1	silt-sandy silt diamicton, stoney
3	silty sand-sand diamicton
3.1	silty sand-sand diamicton, stoney
2	diamicton, texture unknown
1	bedrock
1.1	sandstone
1.2	siltstone
1.3	claystone
1.4	mudstone
1.5	limestone
1.6	shale
1.7	dolomite
1.8	potential bedrock
1.9	coal

Using the ESRI® ArcGIS® ordinary kriging function, northing, easting and elevation points from wells with bedrock lithologies are used to interpolate an initial bedrock topography surface. Following kriging, the bedrock topography surface is inspected manually to identify anomalous depressions or peaks in the bedrock surface. These anomalies, often referred to as "bull's eyes," in the bedrock are typically caused by wells with bedrock elevations that greatly depress or elevate the interpolated bedrock surface compared to surrounding points. Further inspection of bull's eyes determined the validity of the bedrock elevations for these wells. Based on this inspection, bedrock elevation points in these wells were adjusted or removed from the dataset. The dataset was re-interpolated, honouring these well points. The interpolated bedrock surface was then compared to a digital elevation model (DEM), to make sure that the bedrock surface only intersected the DEM where AGS geologists documented bedrock outcrops. Lastly, a sediment thickness map was produced by subtracting the bedrock elevation surface from the DEM. Ongoing field work allows AGS geologists to validate the maps.

Riverbank at Rundle Park in Edmonton showing white precipitate from groundwater seeps. The water is coming from the Horseshoe Canyon Formation.

Conclusions

The outlined methodology enabled the generation of bedrock topography and sediment thickness maps for the ECC. This approach allows for the rapid integration and analyses of large and multiple datasets compiled from various sources. This, in turn, allows for enhanced map quality and increased confidence in geological interpretations. These maps will form the basis for AGS groundwater mapping work in the interval above the bedrock surface and contribute to meeting the Government of Alberta goals included in the Water for Life strategy and the Land Use Framework policies. ❖

Recently Released Publications

Digital Dataset

DIG 2009-0003 Compilation of Alberta Research Council's Hydrogeology Maps (GIS data, polygon features). This accompanies Open File Report 2009-02

Open File Reports

OFR 2008-08 What is Shale Gas? An Introduction to Shale-Gas Geology in Alberta. 5.69 MB PDF

OFR 2008-09 Geochemical and Sedimentological Investigation of the Colorado Group for Shale Gas Potential: Initial Results. 26.90 MB PDF

OFR 2008-10 Geochemical and Sedimentological Investigation of Banff and Exshaw Formations for Shale Gas Potential: Initial Results. 33.95 MB PDF.

OFR 2009-02 Compilation of Alberta Groundwater Information from Existing Maps and Data Sources. 31.31 MB PDF

OFR 2009-04 Description of the Process for Defining the Base of Groundwater Protection. 12.62 MB PDF

OFR 2009-09 Importance of Geoscience Information in the Implementation of Closed-Loop Ground-Source Heat-Pump Systems (Geoexchange) in Alberta. 10.13 MB PDF.

OFR 2009-11 Simulation of Geothermal Flow in Deep Sedimentary Basins in Alberta. 812 KB PDF.

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Conferences Involving Alberta Geological Survey

Alberta Urban Municipalities Association
November 4-5, 2009
TELUS Convention Centre
Calgary, Alberta

Canadian Society for Unconventional Gas
November 18 to 20
Telus Convention Centre
Calgary, Alberta

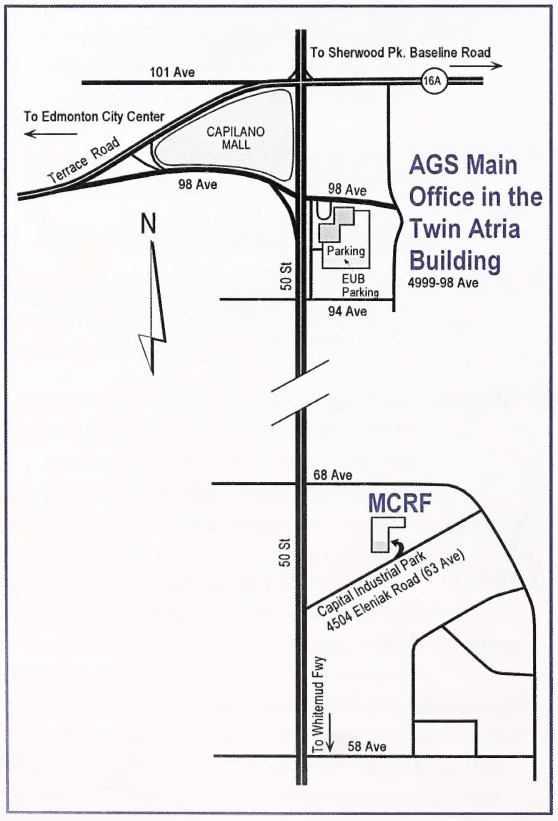
Rock Chips is

This will be the last printed edition of our newsletter.

Rock Chips will still be available on our website in PDF format to read and download. Subscribe to our RSS feed to find out when our latest issue is released.
http://www.ags.gov.ab.ca

We will also continue with our podcasts of the articles. You can subscribe to our podcasts through iTunes, Podcast Alley and via the RSS Podcast link at http://ags.gov.ab.ca/publications/ROCKCHIPS/rockchips.html.

We are also on Facebook, Twitter, FriendFeed, YouTube and LinkedIn.



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Our Mineral Core Research Facility (MCRF) is located at
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Edmonton, Alberta

For information on the MCRF or to book a visit, contact Rob Natyshen by phone at (780) 466-1779 or by e-mail at Rob.Natyshen@ercb.ca